WATERSHED PROGRAM ABSTRACTS

9:00 – 9:25 **Dynamics of floodplain ecosystems: preliminary results – Tim Beechie, Ali Senauer, Martin Liermann, and Blake Feist**

Abstract - Historically, many productive salmon habitats in the Pacific Northwest were located in complex river / floodplain systems. Today many of these areas have been leveed, dammed, and converted to other land uses, thereby separating rivers from their floodplains and associated off-channel habitats. Restoring or rehabilitating these systems requires understanding the natural dynamics of these floodplain ecosystems in order to predict river responses to various restoration actions. This study has two main components: (1) describing spatial patterns of river dynamics within river channel networks, and (2) describing the spatial and temporal dynamics of ecosystem attributes within a pilot reach of the Sauk River, Washington. The first component is focused on understanding where different channel patterns occur and how those patterns might determine the dynamics of river / floodplain ecosystems. The second component focuses on describing ecosystem dynamics by coupling analyses of floodplain patch dynamics with field measures of ecosystem attributes. We describe floodplain patch dynamics by constructing a matrix of transition probabilities among habitat types based on a historical sequence of aerial photographs. We then empirically describe changes in spatial patterns of morphological and biological components such as landform, habitat type, vegetation, and invertebrate or fish communities.

9:25 – 9:50 **Coarse sediment storage by large woody debris in headwater streams – Michael Pollock, Jill Silver (Northwest Indian Fisheries Commission)**

Abstract - The amount of sediment stored by large woody debris in small headwater streams of old-growth coniferous forests of the Pacific Northwest is not well documented. Most studies of sediment storage in small streams have focused on managed sites where the amount and size of wood in streams is considerably smaller than their old-growth counterparts, resulting in an underestimate of the sediment storage capacity of small streams under natural conditions. We hypothesize that the large size and abundance of LWD in old-growth headwater streams will result in higher amounts of sediment being stored as compared to streams in managed forests and that forest management practices in headwater areas has greatly reduced the sediment storage capacity of small streams. We are testing this hypothesis by measuring LWD volumes and sediment volumes stored behind LWD in managed and unmanaged headwater streams of the Olympic Peninsula, Washington. Preliminary results suggest that there is high variability in the amount of sediment and wood storage in small streams and that it may be related to watershed morphology and properties of the parent geology. Preliminary results also suggest that there is far more sediment and wood stored in old-growth systems, relative to nearby managed systems.

9:50 – 10:15 **A broad-scale habitat inventory for the Willamette – Lower Columbia: Approach and applications – Ashley Steel and Mindi Sheer (Conservation Biology, NWFSC)**

Abstract - Landscape and land-use processes occur over broad spatial scales. These processes (e.g. erosion, channel migration) have direct controls on in-stream habitat conditions (e.g. pool density, substrate, water temperature) which, in turn, are determining factors in salmonid abundance and productivity. Managing salmonid populations to the best of our abilities will require quantitative understandings of these relationships over large geographic areas. We have developed an inventory approach to provide the building blocks for these analyses. It consists of five steps: (1) generating stream networks at a 1:24,000 scale, (2) segmenting the stream network using variation in topography and channel slope, (3) calculating channel characteristics for each reach (e.g. channel gradient), (4) identifying all stream segments as currently accessible or inaccessible, (5) linking each stream segment with the available geospatial habitat data layers. We demonstrate three uses of this inventory system for current

recovery planning efforts in the Willamette and Lower Columbia basins. First, we present an approach to estimating extinction thresholds based on kilometers of available habitat of varying types. Second, we describe the use of the inventory, in combination with the SWAM model, to make predictions about potential relative steelhead occupancy. And, third, we present preliminary work on developing models to predict in-stream conditions from landscape and land-use characteristics.

10:30 – 10:55 **Factors affecting food webs in Pacific Northwest streams – Peter Kiffney, Beth Sanderson (Environmental Conservation, NWFSC), and Phil Roni**

Abstract - Streams and rivers in the Pacific Northwest (PNW) drain a diverse landscape comprised of widely differing ecosystems such as temperate, rain forests, alpine tundra and high desert. One characteristic that links these diverse ecosystems is the presence of Pacific salmon. These fishes spend part of their life cycle rearing in streams and rivers of the PNW, and accumulate large amounts of organic matter and nutrients while in the productive North Pacific Ocean, and return to spawn and die in their natal streams. Salmon carcasses function as fertilizer in these streams and are important drivers of the productivity of PNW watersheds. Studies that examine factors controlling food webs and ecosystem productivity in the PNW have increased over the past 10 years; however, the primary research focus has been on how salmon use physical space. As a result, millions of dollars have been spent on enhancing or restoring physical characteristics of watersheds. This focus ignores the fact that some species of anadromous salmonids are important components of stream food webs and controllers of ecosystem productivity. We present results from a number of observational and experimental studies at different temporal and spatial scales across the PNW that examine both physical and biological controls on stream food webs and ecosystem productivity. At the reach scale, our studies suggest that disturbances, such as landslides and logging, have long-term impacts on primary and secondary productivity (decades to centuries). Between these disturbance events, shade and availability of essential nutrients, such as nitrogen and phosphorus, can control stream communities, for example by influencing the abundance and biomass of primary producers and consumers. At large spatial scales and over long time periods, our results support the notion that productivity of food webs in Pacific Northwest streams is frequently limited by availability of limiting resources (nutrients and light).

10:55 – 11:20 **Utilization of nitrogen from spawning salmon by juvenile chinook salmon and steelhead in two tributaries of the Columbia River – Todd Bennett, Phil Roni, and Bob Bilby (Weyerhaeuser Company)**

Abstract - We utilized nitrogen (N) stable isotope ratios of muscle tissue from juvenile chinook salmon and steelhead collected at 25 sites in the Salmon River and John Day River watersheds to evaluate the extent to which N from spawning salmon was utilized by the young fish. By comparing N stable isotope ratios between juvenile anadromous fishes and resident trout located upstream from a barrier to salmon passage, we found evidence of salmon-derived N in juvenile chinook at 24 of the 25 sites and at 17 of the 25 sites for steelhead. N stable isotope ratios in the juvenile anadromous fish were too high at most of the sites to be accounted for simply by contributions of salmon-derived N from the egg, indicating dietary incorporation of this material. Biomass of juvenile anadromous salmonids was positively related to the abundance of carcass material deposited at a location, suggesting that the spawning salmon may be influencing aquatic productivity and hence, the food availability for the rearing fishes. The amount of carcass material deposited at our study sites was low; never over 15 g/m^2. These deposition rates are estimated to be about 1% of the historical rate in these watersheds. Nonetheless, we estimate that up to 20% of the N in the muscle tissue of the juvenile fish was contributed by the spawning salmon. Thus, even at the currently depressed levels of salmon returns to the Columbia River Basin, salmon do make a measurable contribution to N availability in streams. This fact also suggests that even modest increases in salmon escapement may enhance the capability of freshwater systems to support juvenile salmon and trout.

11:30 – 11:55 **Statistical approaches to the analysis of fish density data – Martin Liermann, Ashley Steel, Michael Rosing (Greenland Institute of Natural Resources), and Peter Guttorp (University of Washington)**

Abstract - Ratio data, observations in which one random value is divided by another random value, present unique analytical challenges. The best statistical technique for a particular situation varies depending on the unit of inference and the joint distribution of the numerator and denominator. We present several fish density data sets where one group is compared to another (for example, density in pools vs. density in riffles). We compare standard approaches to drawing inference about differences between the groups: t-tests, t-tests with transformations, randomization tests, non-parametric tests, and ANCOVA-based tests. Comparisons between tests were based both on achieving the specified alpha-level and on statistical power. The tests performed comparably with a few notable exceptions. We develop a few simple guidelines for choosing a test. They are based on the unit of inference and relationship between the numerator and denominator.

11:55 – 12:20 **Evaluating persistence of chinook salmon using habitat-specific models – Correigh Greene, Mary Ruckelshaus (Conservation Biology, NWFSC), Tim Beechie, and Eric Beamer (Skagit System Cooperative)**

Abstract - Efforts to improve the viability of salmon populations depend on understanding the multiple consequences of habitat change, but our ability to predict these consequences is often hampered by a poor understanding of the spatial relationships among critical habitats, and the ways in which salmon utilize these environments. Using data from chinook salmon in the Skagit and Stillaguamish Rivers, we constructed a density-independent age-based model tied to residency in streams, estuaries, Puget Sound, and the ocean. To this basic model we added density dependence at two habitat stages: competition for space in estuary habitats and competition for redds during spawning in streams. We compare both density-independent and density-dependent models to assess how density dependence changes the likelihood of persistence and the rank order of habitat importance for chinook salmon.

1:30 – 1:55 **Abundance and distribution of juvenile salmonids and three forage fish species in nearshore waters of Skagit Bay, Puget Sound, Washington: results from the 2001 townet pilot study - Casey Rice, Eric Beamer (Skagit System Cooperative), Dan Lomax (Ecotoxicology Program, NWFSC), Rich Henderson (Skagit System Cooperative), and George Pess**

Abstract - From May through October 2001, members of the Northwest Fisheries Science Center's (NWFSC) Environmental Conservation Division (ECD), in cooperation with the Skagit System Cooperative (SSC), conducted a pilot project exploring the utility and feasibility of nearshore surface trawling for juvenile chinook salmon (Oncorhynchus tshawytscha) in Skagit Bay, Washington. The project was motivated by two research needs: identification and characterization of chinook life history types present in Skagit Bay; and the collection of chinook abundance data for use in fish production models for the Skagit River system. During the six monthly sampling trips eleven sites (eight of which were adjacent to SSC beach seining locations) were visited, and a total of 115 successful tows were completed. Catch and length frequency records were kept for all salmon, and complete catch records were kept for all fish species encountered. Lengths and weights were measured on all chinook, 122 wild chinook were sampled for otoliths and stomach contents, and a subset of carcasses from the sacrificed wild fish were retained for possible chemical and genetic analyses. In addition, length frequency data were collected on the three most common "forage fish" species present in the bay: Pacific herring (Clupea pallasii), surf smelt (Hypomesus pretiosus) and sand lance (Ammodytes hexapterus). Adipose fin clip and coded wire tag marking of sub-yearling released hatchery chinook in the Skagit River system

has been close to 100% since 1995. This provides unique opportunities for comparing wild and hatchery fish throughout the system, including the relatively understudied estuarine and marine environments. Consistent with expectations regarding life history diversity and use of estuarine habitats, wild chinook showed broader distributions than hatchery chinook with respect to time, space, and length; and had less uniform condition factors (K). When compared to beach seine results, chinook presence in the townet samples persisted later in the year, and the overall proportion of wild chinook in townet catches was much lower (approximately 95% versus 50% for beach seine and townet, respectively), further supporting the hypothesis that estuarine habitats are particularly important to wild chinook.

1:55 – 2:20 **Predicting steelhead redd density in the Willamette River basin from landscape characteristics – David Jensen, Ashley Steel, Blake Feist, George Pess, Bob Bilby (Weyerhaeuser Company), and Jody Brauner (University of Washington)**

Abstract - We analyze the relationship between coarse-scale habitat characteristics and winter steelhead (Oncorhynchus mykiss) abundance in the Willamette River basin. Habitat quality and quantity are key variables influencing salmon population trends in the Pacific Northwest; yet basic relationships between fish abundance and coarse-scale habitat characteristics such as geology and land-use have not been established. Temporal variability in population indices makes habitat / productivity relationships difficult to detect in any one stream. We have found that, despite annual fluctuations in escapement, certain areas within the watershed consistently produce the majority of spawners. To quantify this relationship, we spatially linked redd counts to multiple layers of habitat data available at broad spatial scales (geology, mean annual air temperature, road density, land use and forest cover). To test for statistical significance of observed patterns, we used mixed linear models. Mixed models allow for the inclusion of both fixed and random covariates. They were used here to model the correlation between redd counts taken over time at the same site, thus improving our estimation of the influence of the various covariates. Using this technique, we identified a suite of models that associate habitat characteristics with the reaches that consistently support a large number of spawners. Four models were ultimately chosen based on their ability to consistently predict redd density at sites for which we have count data; they included a combination of geological characteristics, vegetative cover, land form, and land use. These models will be used to identify locations within the basin that might support unusually high numbers of fish and to predict potential relative abundance in areas that are currently inaccessible to steelhead.

2:30 – 2:55 **A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds – Phil Roni, Tim Beechie, George Pess, Michael Pollock, Frank Leonetti (Snohomish County Public Works), and Bob Bilby (Weyerhaeuser Company)**

Abstract - Millions of dollars are spent annually on watershed restoration and stream habitat improvement in the Pacific Northwest United States in an effort to increase fish populations. It is generally accepted that watershed restoration should focus on restoring natural processes that create and maintain habitat rather than manipulating instream habitats. However, most process-based restoration is site-specific, i.e., conducted on a short stream reach. In an effort to synthesize site-specific techniques into a process-based watershed restoration strategy, we reviewed the effectiveness of various restoration techniques at improving fish habitat and developed a hierarchical strategy for prioritizing them. The hierarchical strategy we present is based on three key elements: 1) principles of watershed processes, 2) protecting existing high-quality habitats, and 3) current knowledge of effectiveness of specific techniques. Initially, efforts should focus on protecting areas with intact processes and high-quality habitat. Following a watershed assessment, we recommend that restoration focus on reconnecting isolated high-quality fish habitats such as instream or off-channel habitat made inaccessible by culverts or other man-made obstructions. Once the connectivity of habitats within a basin has been restored,

efforts should focus on restoring hydrology, geologic (sediment delivery and routing), and riparian processes through road decommissioning and maintenance, exclusion of livestock, and restoration of riparian areas. Instream habitat enhancement (e.g., additions of wood, boulders, or nutrients) should be employed only after restoring natural processes or in cases where short-term improvements in habitat are needed (e.g., habitat for endangered species). Finally, existing research and monitoring is inadequate for all the techniques we reviewed and additional comprehensive physical and biological evaluations of most watershed restoration methods are needed.

3:10 – 3:35 **Restoration of off-channel habitats for Pacific salmon - Sarah Morley, Patsy Garcia, Todd Bennett, and Phil Roni**

Abstract - Off-channel habitats (such as sloughs, beaver ponds, wetlands and other permanently or seasonally flooded lands) are important rearing areas for juvenile salmonids. As floodplains have been routinely isolated or impacted by adjacent land use practices, off-channel habitats have been lost. The objectives of this project are to determine the effectiveness of various off-channel habitat restoration techniques by 1) gathering and summarizing known information on off-channel salmonid production, and 2) determining what physical, biological, and hydrological features characterize the most successful projects. Based on analysis of smolt-trapping data from over 30 off-channel sites in Washington State, we found that constructed groundwater channels were particularly productive for juvenile coho salmon (Oncorhynchus kisutch). We began the field collection component of our study by testing methods for fish density estimation at a subset of constructed groundwater channels in the Skagit River Basin, Washington. We observed five salmonids species using these off-channel habitats, although coho comprised 94% of fish present at constructed sites and 58% in reference channels. We also collected temperature, nutrient, and invertebrate data so as to evaluate the specific relationships between these site characteristics and fish use parameters. Knowledge of these relationships will help to establish future guidelines for the design and construction of off-channel habitats.

3:35 – 4:00 **The truth about non-indigenous species in Pacific Northwest estuarine ecosystems - Blake Feist and Peter Kareiva (The Nature Conservancy)**

Abstract - Worldwide, non-indigenous species (NIS) are considered one of the top threats to the world's ecosystems. Their perceived malignancy is rivaled only by the impact of habitat loss and alteration. The irony of this situation lies in the fact that there is often very little compelling evidence supporting the allegation that NIS are in fact a primary contributor to worldwide biodiversity decline, habitat loss, and ecosystem collapse. For example, there have been a handful of documented extinctions in the United States, and over 4,000 introductions. This hardly constitutes a NIS-borne biodiversity crisis.

The Pacific Northwest is not without its own collection of non-indigenous species and associated perceived threats. Vast amounts of money are spent each year trying to control or eradicate various non-indigenous species, under the assumption that various ecosystems and their associated federally listed species are in danger of being overrun. Given the myriad anthropogenic problems confronting our society, our resources and time might, in some cases, be better spent combating the impacts of global climate change, deforestation, and urbanization.

Here, I present an overview of the perceived problems of NIS, what is being done to control or eradicate them in the Pacific Northwest, and what these efforts might be doing to the ecosystems we are trying to protect. I will provide a few case studies, with an emphasis on estuarine ecosystems that illustrate how our reaction to NIS might be more detrimental than the presence of the "invaders" themselves. While my perspective may seem heretical by many, it is not without basis and is worthy of consideration.

4:00 – 4:25 **Response of the riverine ecosystem to altered sediment and wood supply downstream of Elwha Dams – George Pess, Michael McHenry (Lower Elwha S'Klallam Tribe), Tim Beechie, and Peter Kiffney**

Abstract - Since installation of the first Elwha dam in 1912, decreased sediment and wood supply to the lower Elwha River has resulted in river entrenchment, degeneration of floodplain habitats, decreased abundance of certain riverine habitats, and distinct patterns of juvenile salmon occupancy of these habitats. Impending removal of these dams presents an opportunity to explore linkages among changes in sediment supply, in-channel wood abundance, and habitat and ecosystem attributes. Sampling of ecosystem attributes before and after dam removal, as well as in nearby reference rivers will elucidate functional relationships among sediment and wood supply, formation and persistence of river and floodplain habitats, and resultant ecosystem dynamics. Preliminary data indicate distinct floodplain habitat types related to the connectivity of main river and off channel stream flows. Such relationships provide a basis for predicting ecosystem responses to changes in river dynamics after dam removal.